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RESEARCH ARTICLE

Factors associated with blood product requirements during the transoperative period in pediatric patients

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Abstract

Background: *The efficiency of blood products (BP) requisition in elective non-cardiac surgeries is inherently complex. Moreover, it is aggravated in the pediatric population. This study aimed to identify the factors associated with using less than the requested BP during the transoperative period in pediatric patients undergoing elective non-cardiac surgery.* **Methods:** *We conducted a cross-sectional comparative study including 320 patients undergoing elective non-cardiac surgery for whom BPs were requested. Low requirements were considered when less than 50% of the requested amount or no BPs were used, and high requirements when more than the requested amount was used. The Mann-Whitney's U test was applied for comparative analysis, and multiple logistic regression was used to adjust for factors associated with lower requirements.* **Results.** *The median age of the patients was 3 years. From 320 patients, 68.1% (n = 218) received less than the requested amount of BP, while only 1.25% (n = 4) received more than the requested amount of BP. Factors associated with transfusion of less than the requested BPs were prolonged clotting time (odds ratio (OR) = 2.66) and anemia (OR = 0.43).* **Conclusions:** *Factors associated with lower than requested BP transfusion were prolonged clotting time and anemia.*

Keywords: *Blood transfusion. Pediatric. Elective surgical procedures.*

Factores asociados a los requerimientos de productos sanguíneos durante el transoperatorio en pacientes pediátricos

Resumen

Introducción: *La eficiencia de la solicitud de productos sanguíneos (PS) en las cirugías electivas no cardiacas es, de por sí, compleja. No obstante, se agrava para la población pediátrica. El objetivo de este estudio fue identificar los factores asociados con la utilización de una cantidad de PS menor a la solicitada durante el transoperatorio en pacientes pediátricos sometidos a cirugía electiva no cardiaca.* **Métodos:** *Se realizó un estudio transversal comparativo donde se incluyeron 320 pacientes sometidos a cirugía electiva no cardiaca para quienes se solicitaron PS. Los requerimientos de hemoderivados se consideraron como menores cuando no se utilizaron o se utilizó menos del 50% de lo solicitado y como mayores cuando se utilizó una cantidad mayor a la solicitada. Se aplicó la prueba U de Mann-Whitney para el análisis comparativo y regresión logística múltiple para ajustar los factores asociados a la presencia de menores requerimientos.* **Resultados:** *La mediana para la edad de los pacientes fue de 3 años. Se transfundió una cantidad de PS menor a la solicitada en el 68.1% (n = 218) de los pacientes, mientras que se transfundió una cantidad mayor a la solicitada solo en el 1.25% de los pacien-*

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tes (n = 4). Los factores asociados con la transfusión de una cantidad de PS menor a la solicitada fueron tiempos de coagulación alargados (TCA) (razón de momios (RM) = 2.66) y anemia (RM = 0.43). **Conclusiones:** *Los factores asociados a una transfusión de PS inferior a la solicitada fueron el tiempo de coagulación prolongado y la anemia.*

Palabras clave: *Transfusión sanguínea. Pediatría. Cirugía electiva.*

Introduction

The aim of blood product (BP) transfusion should be the treatment of specific processes when there is no alternative therapy or it is not possible to wait for the response of other treatments[1]. The indication for transfusion should be established according to primary objectives: maintenance or increase of oxygen transport to tissues, control of bleeding, and normalization of coagulation disorders[2].

Although blood transfusion provides undeniable clinical benefits, it is not a risk-free process. Also, it involves the consumption of a resource that is difficult to replace and, on many occasions, scarce. Published reports on blood products show that approximately 60% of all blood transfusions are administered in the operating room. For these reasons, it is essential to adjust transfusions to the real needs of each case[3,4].

The decision on the amount of BP requested before elective non-cardiac surgery can be complex. In general, the recommendation is to have a sufficient stock of BP in case of an unforeseen event during surgery. However, sometimes these units are not used. This has resulted in staff overload, waste of reagents, depletion of blood bank resources, and additional financial burdens for the patient and the institution. In the literature, up to 70% of surplus requests for blood products have been reported in different institutions[5,6].

Requesting BPs and their quantity is part of the preoperative evaluation. Therefore, on many occasions, this decision depends on the anesthesiologist's or inexperienced physicians' judgment. Therefore, using strategies in which physicians can make data-driven decisions to identify patients at high risk for transoperative bleeding has been justified[7,8].

Knowing the proportion of surgical procedures with lower or higher BP requirements in pediatric patients and identifying the factors associated with such conditions may help both to create a strategy to guide physicians and unify BP request criteria based on the patient's presurgical status and to improve the efficiency of BP requests, which would reduce risks and costs for patients and institutions.

This study aimed to identify factors associated with lower-than-requested BP requirements in pediatric patients undergoing elective non-cardiac surgery during the transoperative period.

Methods

We conducted a comparative cross-sectional study in a tertiary pediatric hospital from January to December 2020. We included pediatric patients (0-18 years) undergoing elective non-cardiac surgery and with a BP request. We excluded patients with incomplete medical records.

We obtained demographic and anthropometric data from the clinical records: body surface area, laboratory values before surgery, surgical risk classification according to the American Society of Anesthesiologists (ASA)[9], type of surgery (minor or major), surgical service, and the BPs requested before surgery. From the surgical record, we obtained information on whether the patient received a transfusion, the BP amount used, and the cause of the transfusion.

Patients were classified by age group: neonates (< 28 days old), infants (1 month to 2 years), preschoolers (2 to 6 years), schoolchildren (7 to 10 years), and adolescents (11 to 18 years).

The following definitions were considered: major surgery was defined as any procedure performed in the operating room involving incision, excision, manipulation, or suture of tissue, requiring regional or general anesthesia or deep sedation for pain control. Anemia was considered as the presence of hemoglobin less than two standard deviations for mean age according to sex, thrombocytopenia as a platelet value < 100,000/μL, and prolonged clotting time as values less than the 5th percentile according to age[10,11].

A lower requirement was considered when no BPs or less than 50% of the requested quantity was used. Conversely, a higher requirement was defined when more BPs were used during surgery because transfusion was necessary.

Statistical analysis

The median and interquartile range were calculated for quantitative variables and percentages and

frequencies for qualitative variables. The Mann-Whitney's U test was used to estimate differences between the quantitative variables and χ^2 to compare qualitative variables between the group of patients with BP requirements according to those requested and the group of patients with BP requirements lower than those solicited during the transoperative period. The Mantel-Haenszel test calculated the odds ratio (OR) and confidence interval (95% CI) for overestimating BP requirements. Multiple logistic regression analysis was performed to identify the factors associated with lower BP requirements during the transoperative period. A *p*-value < 0.05 was considered statistically significant. STATA v.16.0 was used for statistical analysis.

This protocol was approved by the hospital's Research and Ethics Committee. Parents signed the informed consent form. Patients > 8 years of age also signed informed consent following the recommendations of the Declaration of Helsinki.

Results

We identified a total of 1609 patients scheduled for elective non-cardiac surgery. Of these patients, blood components were requested in only 320. No patients were excluded.

In these 320 patients, the female sex predominated (60.3%), with a median age of 3 years. The frequency by age group was 32.5% for infants, followed by 29.4% for adolescents. Most patients (88.1%) were scheduled for major surgery, and the surgical service that performed the procedure was general surgery (30%), followed by neurosurgery (21.3%) and oncology (17.8%). According to the American Society of Anesthesiologists physical status classification, 81.6% (n = 261) of the patients were classified as ASA 3.

Preoperative studies showed anemia in 34.7%, thrombocytopenia in 14.1%, and prolonged clotting time in 84.7% of patients. Approximately half of the patients (44.7%, n = 143) required blood products during the transoperative period (Table 1).

Regarding BP transfusion during the transoperative period, the amount of BP requested differed from the amount transfused in 69.4% (n = 222) of the patients. In 68.1% (n = 218) of patients, the amount of BP transfused was less than requested, and only four (1.2%) patients required more BP than requested.

Of the four patients who required more BP, two were neonates (< 5 days), one was an infant (12 months), and the other was an adolescent (11 years). One of the neonates presented severe enterocolitis with thrombocytopenia and hemorrhage during surgery, despite a platelet concentrate transfusion. The other neonate had cholestatic syndrome and showed hemorrhage during transoperative cholangiography, despite standard coagulation times and platelet count. The infant presented with an anorectal malformation and underwent a posterior sagittal anorectoplasty.

Table 1. General characteristics and preoperative studies of the patients

Characteristics	Total (n = 320)
Sex	n (%)
Female	193 (60.3)
Male	127 (39.7)
Age (years)	
Median (interquartile range)	3 (0, 11)
Age group	
Neonate	43 (13.4)
Infant	104 (32.5)
Preschool	50 (15.6)
School-age	29 (9.1)
Adolescents	94 (29.4)
Somatometry	Median (interquartile range)
Weight (kg)	14.0 (3.9, 38.3)
Height (cm)	87.0 (52.0, 137.0)
Body surface area (m^2)	0.60 (0.12, 1.86)
Surgical service	n (%)
General surgery	96 (30.0)
Neurosurgery	68 (21.3)
Oncology	57 (17.8)
Neonatology	44 (13.7)
Other*	42 (13.1)
Thorax	13 (4.1)
Type of surgery	n (%)
Major surgery	282 (88.1)
American Society of Anesthesiologists classification	n (%)
1	2 (0.6)
2	45 (14.1)
3	261 (81.6)
4	12 (3.7)
Preoperative studies	Median (interquartile range)
Hemoglobin (g/dL)	12.0 (10.3, 13.5)
Hematocrit (%)	36.0 (31.5, 40.5)
Prothrombin time (s)	12.7 (11.8, 14.0)
Partial thromboplastin time (s)	26.9 (24.7, 31.0)
International normalized ratio (INR)	1.1 (1.0, 1.2)
Platelets (x1000/mm^3)	292.5 (136.0, 411.5)
Diagnosis	n (%)
Anemia	111 (34.7)
Thrombocytopenia	45 (14.1)
Prolonged clotting time	271 (84.7)

*Other: plastic surgery, maxillofacial surgery, ophthalmology, orthopedics, otorhinolaryngology, transplantation, or urology.

The adolescent had a history of abdominal trauma and was scheduled for ileostomy closure; both patients showed adhesions, which caused more bleeding than expected.

When comparing the group of patients with BP requirements matching those requested and the group of patients with lower BP requirements, it was detected that hemoglobin (12.3 g/dL vs. 11.1 g/dL; $p < 0.001$), hematocrit (37.0% vs. 33.1%; $p < 0.001$) and platelet levels (308,000 vs. 250,500; $p < 0.001$) were higher in patients requiring less BP than requested. When comparing alterations according to pre-surgical studies, patients with lower BP requirements presented a lower proportion of anemia (28% vs. 49%; $p < 0.001$), thrombocytopenia (10.6% vs. 21.4%; $p = 0.010$), and more prolonged clotting time (89.4% vs. 74.5%; $p = 0.001$) than patients with BP requirements matching those requested. No other differences were observed between the groups (Table 2).

A multivariate analysis was performed to identify factors associated with lower BP requirements than those requested during the transoperative period. We determined that prolonged clotting time (OR = 2.66) increased the probability of ordering more than required. At the same time, anemia (OR = 0.43) was a factor that decreased the probability of requesting less than solicited (Table 3).

Discussion

Among the main findings of this study, we identified that the amount of BP requested differed from that transfused in 69.4% (n = 222) of the patients; of these patients, only 1.2% required more BP than requested.

Appropriate ordering of BP for administration during surgery can be critical and life-saving[12]. In the adult population, physicians adopt guidelines for preoperative BP ordering based on blood loss prediction, laboratory studies, and preoperative clinical assessment (local maximum surgical blood order schedule)[13,14]. However, in pediatric patients, blood ordering lacks guiding principles because children have smaller blood volumes, and minimal blood loss requires transfusion of blood components to maintain adequate tissue oxygenation[6,15]. Thompson et al. confirmed a tendency to request more blood components in younger patients[16].

A challenge currently faced is that 30-70% of the BP requested for different surgical procedures is not transfused. On the one hand, requesting more BPs than required could limit its use for other patients and increase hospital costs[17,18]; on the other hand, being unprepared for inadvertent events during surgery can put the patient's life at risk. In this study, we identified that the amount of BP requested differed from that administered in 69.4% (n = 222) of the patients, consistent with the literature.

Age (infants less than one-month-old) and ASA 4 have been reported as factors associated with the difference between the amounts of BP requested and administered[12]. However, these factors were not observed in the present study, probably because other elements were analyzed, such as altered preoperative studies, with which pediatricians attempt to make more objective decisions on BP requests, thus reducing the risk of age less than one month as a factor. Gálvez et al. analyzed trauma and severe emergency patients[12]. In contrast, our research, conducted in a tertiary pediatric hospital, included primarily patients with complex diseases and multiple comorbidities (n = 273, 85.3%) with a high ASA score (ASA 3-4).

Another critical fact to highlight is the need to document more on the relationship between hemoglobin levels, coagulation time and platelet values, and the risk of transfusion in the transoperative period[4,7,12,14,16,19,20]. In our study, anemia was a condition for which the probability of transfusion of BP less than requested decreased. This observation could be related to the surgeon and anesthesiologist being more aware of hemorrhage and hemodynamic instability. Therefore, any condition out of the expected is enough to initiate an early transfusion[1,21]. Contrastingly, in patients with renal and hemato-oncological diseases, which are frequent in our hospital, physicians avoid BP transfusions despite identifying anemia in the pre-surgical studies because this could lead to future complications due to an increased risk of transfusion reactions and graft-versus-host disease[22,23]. In these patients, BP transfusion is only performed in the case of hemodynamic decompensation unresponsive to other measures[24].

Moreover, the probability of hemorrhage in subjects with altered coagulation times is more challenging to identify. Therefore, in most cases, physicians request BP and evaluate the transoperative conditions (bleeding and vital signs) to transfuse. Thus, each patient's preoperative request for BP in clinical practice should be individualized.

Based on our results, the alteration in coagulation times was identified as the factor that mainly impacted the difference between the BPs requested and those used. This finding indicates adequate preparation of the patient who did not require a BP transfusion despite presenting this preoperative alteration. However, further

Table 2. Comparison of general characteristics and preoperative studies between patients with requirements matching those requested and those with lower requirements than those requested

Characteristics	Requirements for BP during the trans-operative period (n = 316)		OR (95%CI) Overestimation of requirements	*p*-value
	Matching requirements (n = 98)	Overestimation of requirements (n = 218)		
Sex, n (%)				
Female	61 (62.2)	128 (58.7)	1.15 (0.69-1.95)	0.554
Male	37 (37.8)	90 (41.3)	-	
Age (years)				
Median (interquartile range)	2 (0, 11)	3 (0, 11)	0.91 (0.53-1.57)	0.751
Age group, n (%)				
Neonate	13 (13.3)	29 (13.3)	0.99 (0.45-2.09)	0.385
Infant	37 (37.8)	65 (29.8)	-	-
Preschool	10 (10.2)	40 (18.3)	-	-
School-age	9 (9.2)	20 (9.2)	-	-
Adolescents	29 (29.6)	64 (29.4)	-	-
Somatometry				
Weight (kg)**	11.9 (5.5, 32.0)	14.5 (3.9, 40.0)	-	0.312
Height (cm)**	79.0 (52.0, 134.0)	89.0 (52.0, 138.0)	-	0.413
Body surface area (m^2)**	0.53 (0.31, 1.10)	0.62 (0.23, 1.28)	-	0.363
Surgical service, n (%)				
General surgery	25 (25.5)	68 (31.2)	-	0.096
Neurosurgery	25 (25.5)	43 (19.7)	-	-
Oncology	22 (22.5)	35 (16.1)	-	-
Neonatology	14 (14.3)	29 (13.3)	-	-
Other*	12 (12.2)	30 (13.8)	-	-
Thorax	0 (0)	13 (6.0)	-	-
Type of surgery, n (%)				
Major surgery	85 (86.7)	193 (88.5)	1.18 (0.52-2.53)	0.650
ASA, n (%)				
1	0 (0.0)	2 (0.9)	1.17 (0.49-1.19)	0.538
2	12 (12.2)	31 (14.2)	-	-
3	81 (82.7)	179 (82.1)	-	-
4	5 (5.1)	6 (2.8)	-	-
Preoperative studies				
Hemoglobin (g/dL)**	11.1 (9.5, 13.0)	12.3 (10.9, 13.9)	-	< 0.001
Hematocrit (%)**	33.1 (29.0, 38.8)	37.0 (33.0, 41.0)	-	< 0.001
PT (s)**	12.8 (12.0, 14.2)	12.6 (11.8, 14.0)	-	0.296
PTT (s)**	26.9 (24.6, 31.2)	26.7 (24.7, 31.0)	-	0.050
INR **	1.1 (1.0, 1.2)	1.1 (1.0, 1.2)	-	0.292
Platelets (x1000/mm^3)**	250.5 (114.0, 348.0)	308.0 (166.0, 428.0)	-	< 0.001
Diagnosis				
Anemia, n (%)	48 (49.0)	61 (28.0)	0.40 (0.23-0.68)	< 0.001
Thrombocytopenia, n (%)	21 (21.4)	23 (10.6)	0.43 (0.21-0.87)	0.010
Prolonged clotting time, n (%)	73 (74.5)	195 (89.4)	2.90 (1.47-5.70)	0.001

*Other: plastic surgery, maxillofacial surgery, ophthalmology, orthopedics, otorhinolaryngology, transplant, or urology.
**Median (interquartile range). Mann-Whitney's U test was applied for quantitative and χ^2 for qualitative variables. Mantel-Haenszel test was used to calculate the odds ratio (OR) and confidence interval (95% CI).
ASA, American Society of Anesthesiologists physical status classification; CI, confidence interval; INR, international normalized ratio; OR, odds ratio; PT, prothrombin time; PTT, partial thromboplastin time.

studies focused on factors that can better predict BP requirements in pediatric patients with altered coagulation times before surgery to ensure the efficient use of BPs.

One of the limitations of the present study is that transoperative hemodynamic considerations, such as amine requirement, total bleeding, and hourly diuresis, were not considered. These elements would provide

Table 3. Multivariate analysis to identify factors associated with a lower transfusion than the requested blood products (n = 316)

Characteristics	Coefficient (95% CI)		OR (95% CI)		*p*-value
Neonates and infants	-0.06	-0.57, 0.45	0.93	0.56, 1.56	0.808
Major surgery	-0.07	-0.84, 0.70	0.93	0.42, 2.02	0.856
ASA classification	0.04	-0.57, 0.66	1.04	0.56, 1.14	0.719
Thrombocytopenia	-0.45	-1.16, 0.26	0.63	0.31, 1.30	0.215
Anemia	-0.83	-1.36, -0.29	0.43	0.25, 0.74	0.002
Prolonged clotting times	0.98	0.30, 2.44	2.66	1.35, 5.25	0.004

95% CI, 95% confidence interval; ASA, American Society of Anesthesiologists physical status classification; OR, odds ratio.
Intercept: 0.32.

valuable information on the reasons for transfusion in this group of patients. Moreover, since this was a cross-sectional study, it was impossible to define the causality and temporality of the identified factors. For this reason, it is essential to continue with studies to identify predictive factors.

In conclusion, pediatric patients with anemia used the requested BPs more frequently than patients without anemia. However, patients with prolonged clotting time used the requested BP less often than patients without this factor. Therefore, we recommend that the request for BPs should be individualized in patients with prolonged clotting time scheduled for surgery. This practice will help blood banks to be more efficient.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author has this document.

Conflicts of interest

The authors declare no conflicts of interest.

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